

# **Vegetation mapping of Northern Fennoscandia and Kola Peninsula, using Landsat TM/ETM+ data.**

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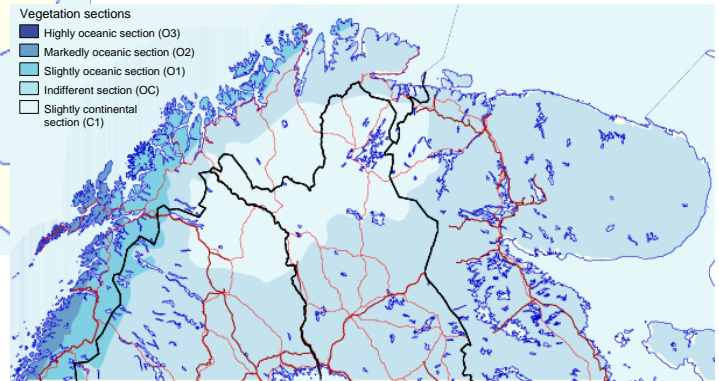
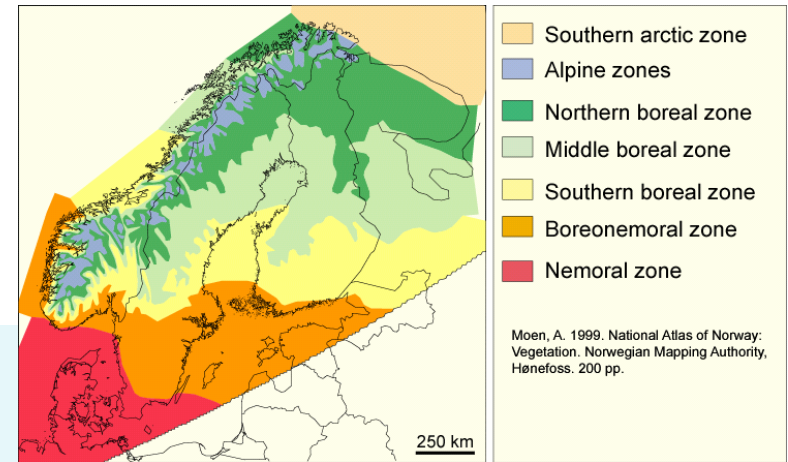
# Northern Fennoscandia and Kola Peninsula

- Represent a transition area between humid, oceanic parts in the west and drier, more flat, continental areas towards the east.
- The area includes a transition from boreal forest in the south to treeless Arctic tundra in the north, interrupted by several large, treeless mountains
- The major bioclimatic zones have been agreed upon within the Nordic countries
- However, different criteria for defining zones/sections have been used within Russia and the former Soviet Union, which is easily seen when comparing these two territories in the European Vegetation Map

# Objectives

- The overall aim of the performed mapping has been to generate a generalized, consistent, and seamless vegetation map for the study area.
- Develop methods for creating large-area vegetation maps based on Landsat TM/ETM+ images
- Create a reasonably accurate land-cover data set appropriate for a wide variety of end-users
- Point out some improvements to the map by combining different satellite data resources

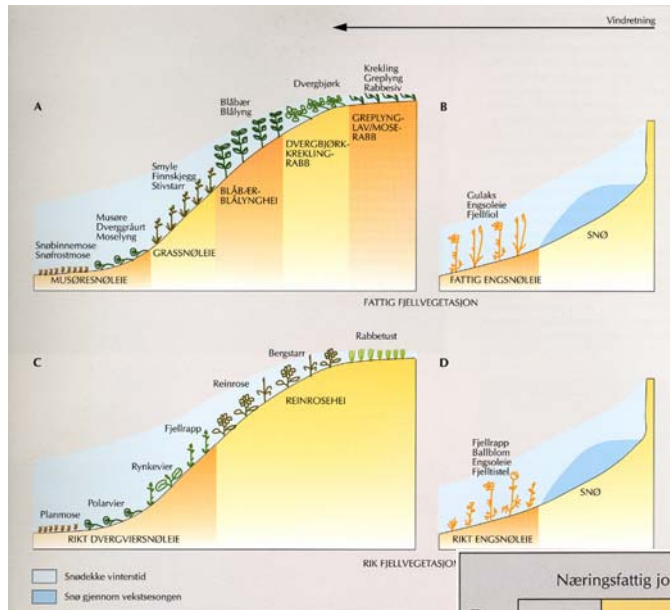
# The study area



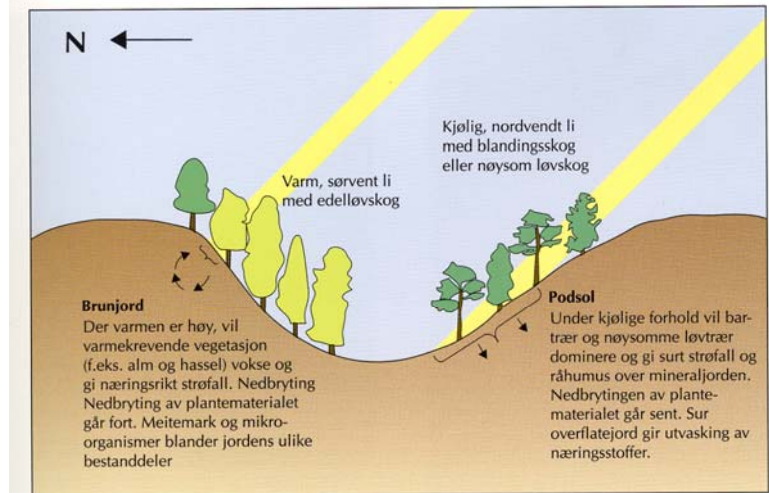


# Vegetation community models

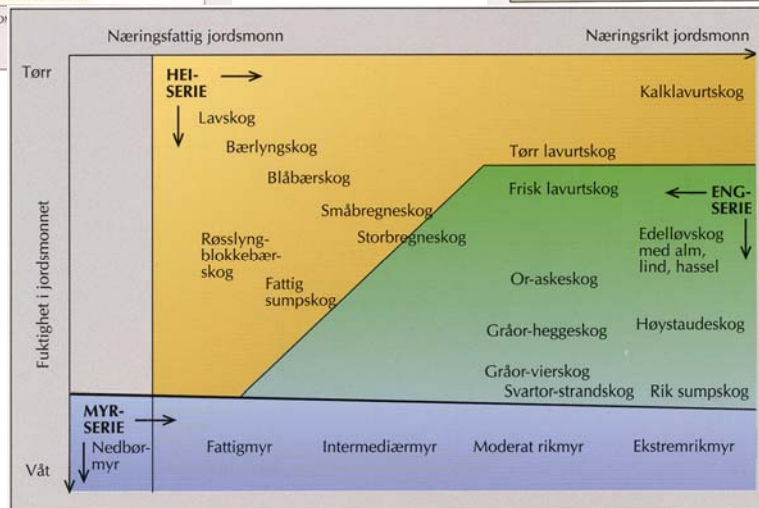
## a) Geology (mountain vegetation)



## b) Slope/aspects (forests)

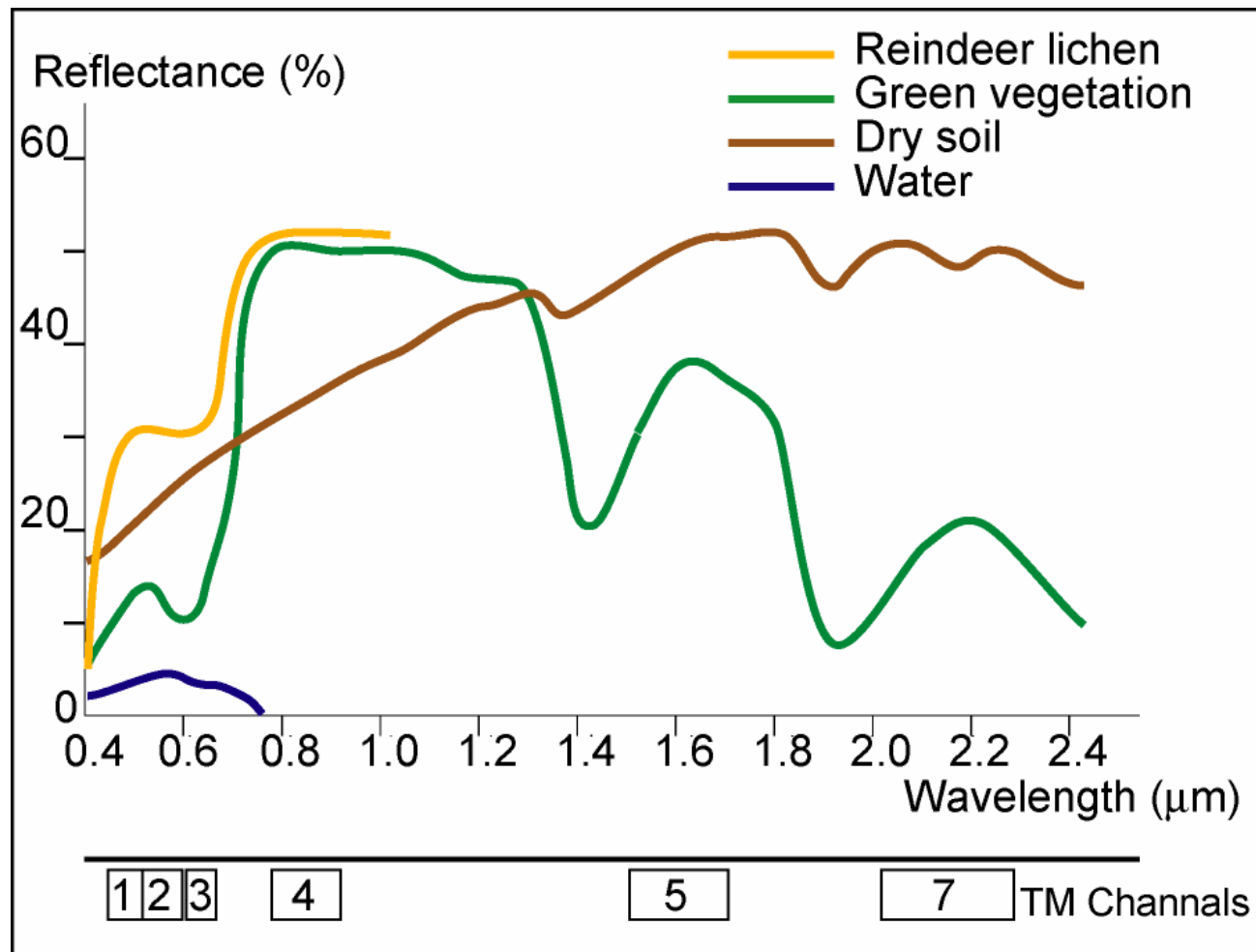


## c) Subsoil and water conditions (forests)



lokale fordeling av vegetasjonstypene. I Norge er det stor forskjell på de ulike jordene. Dette henger sammen med at innstrålt solenergi per areal blir temperaturen i lufta og i jordsmonnet høyere, og både temperaturen og mengden av dødt materiale skjer fortere. En rekke varmekrevende vegetasjonstyper er knyttet til slike sørvendte, varme lier.

## Vegetation classes – spectral characteristics

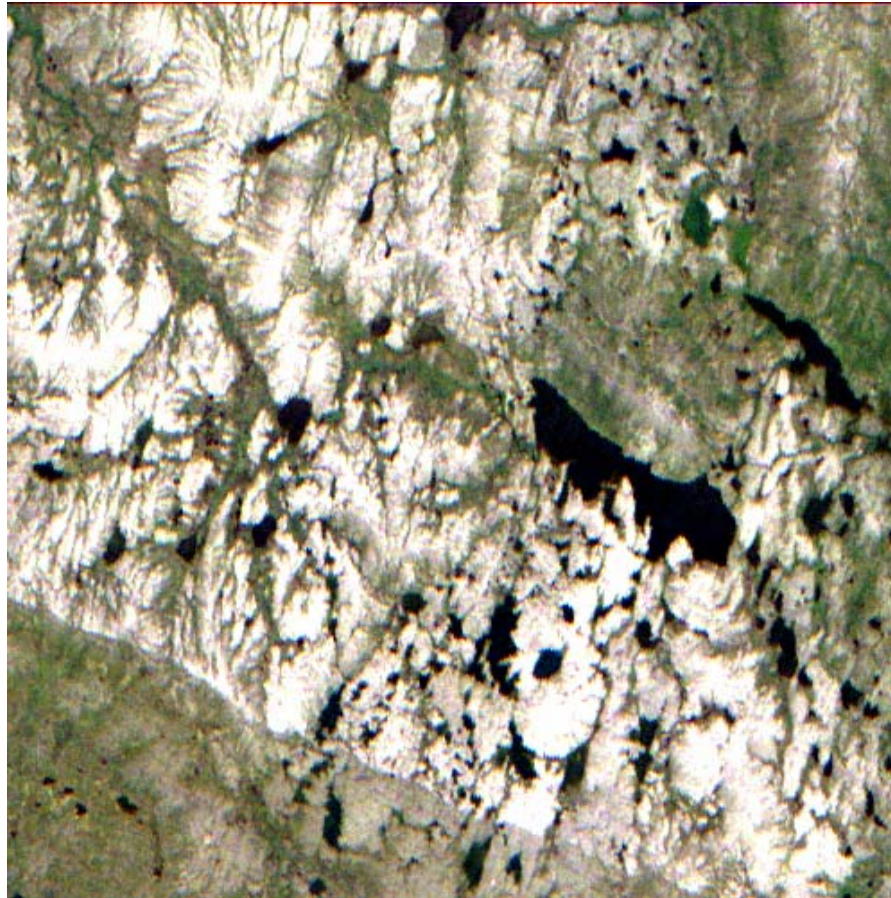


# Border areas – Norway-Finland

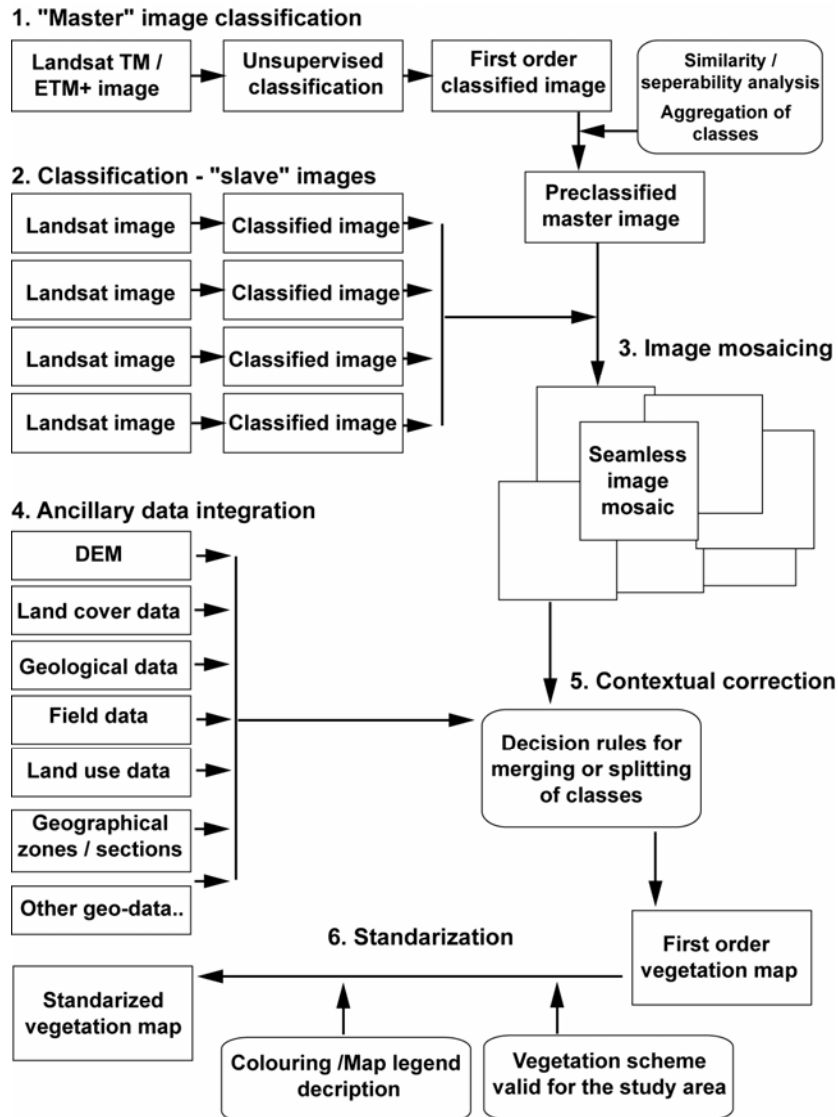




# Border areas- spectral differences



# Classification processing scheme



- Pre-classification: Image classification, spectral analysis, separability analysis, description of spectral classes
- Post-classification: Integration of ancillary data (DEM, land cover data, field inventory data)
- Standardization. Relate the map units to a classification system valid for the area

# Available data layers

- Several Landsat TM/ETM+ images collected from different years in the period 1994-2002
- Ancillary data sources used in this study comprises digital elevation models, digital topographic maps containing separate cover layers of forests, mires, agricultural areas, water, and open areas
- For parts of the mountain regions of Norway a snow cover mask was developed and used in order to differentiate ridge and snow-patch communities in the mountain region
- The map created has been compared to available vegetation maps based on traditional methods (aerial photos/field studies)

# Accuracy assessment

Note: The availability and the quality of the ancillary highly influence the quality of the final map product

- **Norway:** 5 vegetation maps created using traditional methods (aerial photos/field investigations)
- **Sweeden:** a) Several traditional maps along the Norwegian/Swedish mountain range based on traditional methods;  
b) Corine Land Cover maps
- **Finland:** Maps from Corine Land Cover

# Map products

## Vegetation maps:

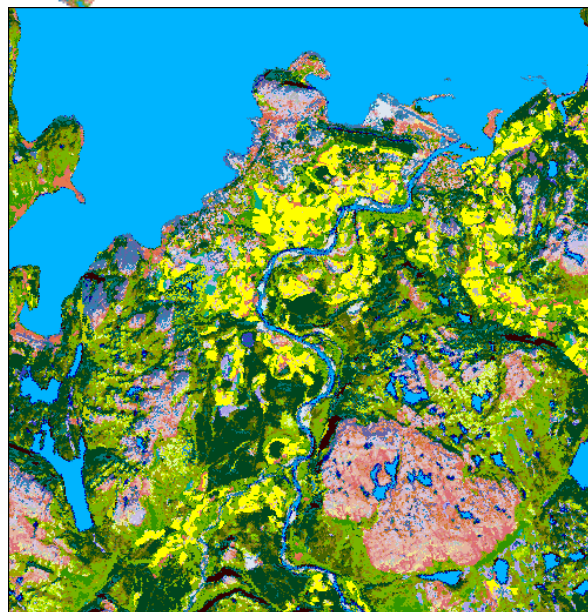
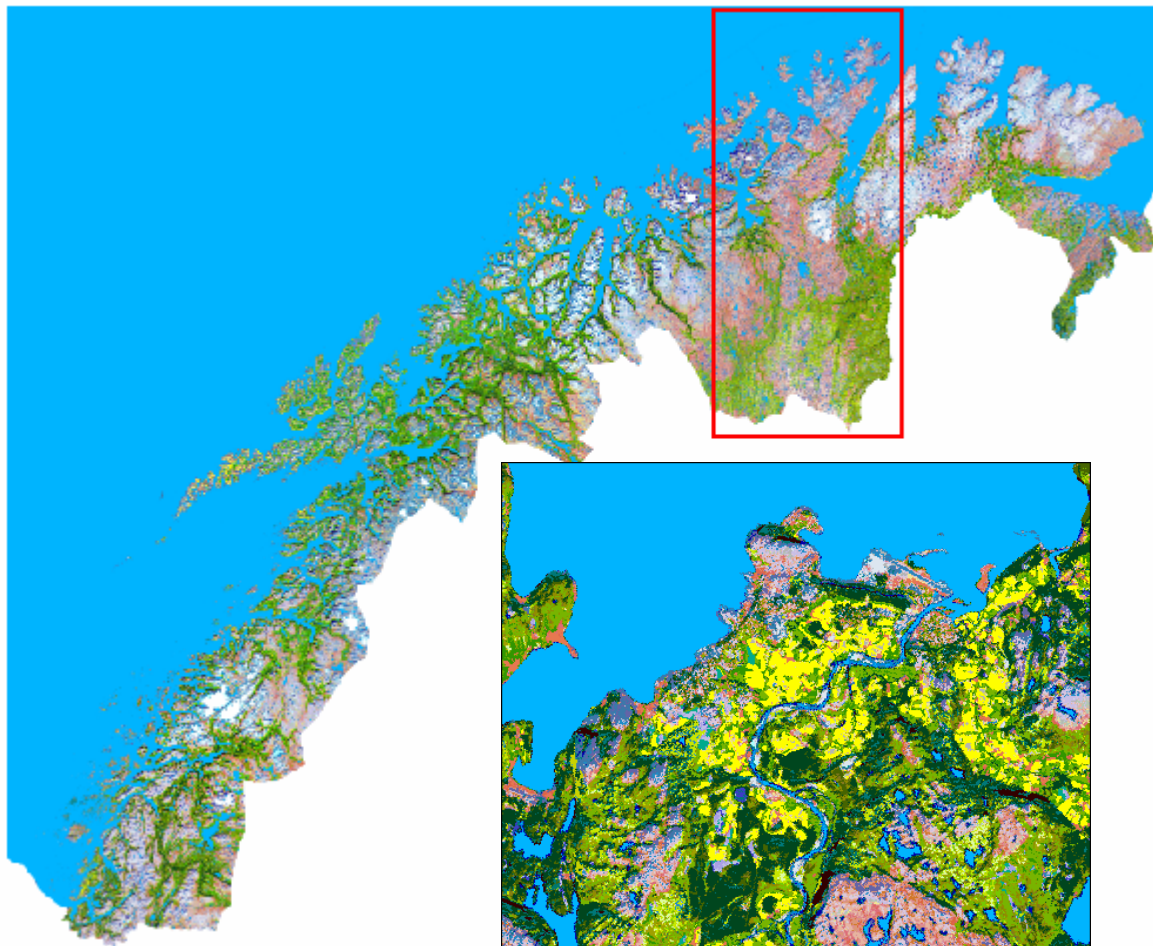
- For areas in Norway ancillary data were available with a resolution of 30 m.
- For areas in Sweden and Finland cover layers of 100 m were used
- Areas on Kola Peninsula are not undertaken any contextual correction due to lack of ancillary data.

## Derived products:

- Eco-regional map
- Snow cover analysis
- Vegetation change maps for Finnmarksvidda
- Map improvements – using SAR data

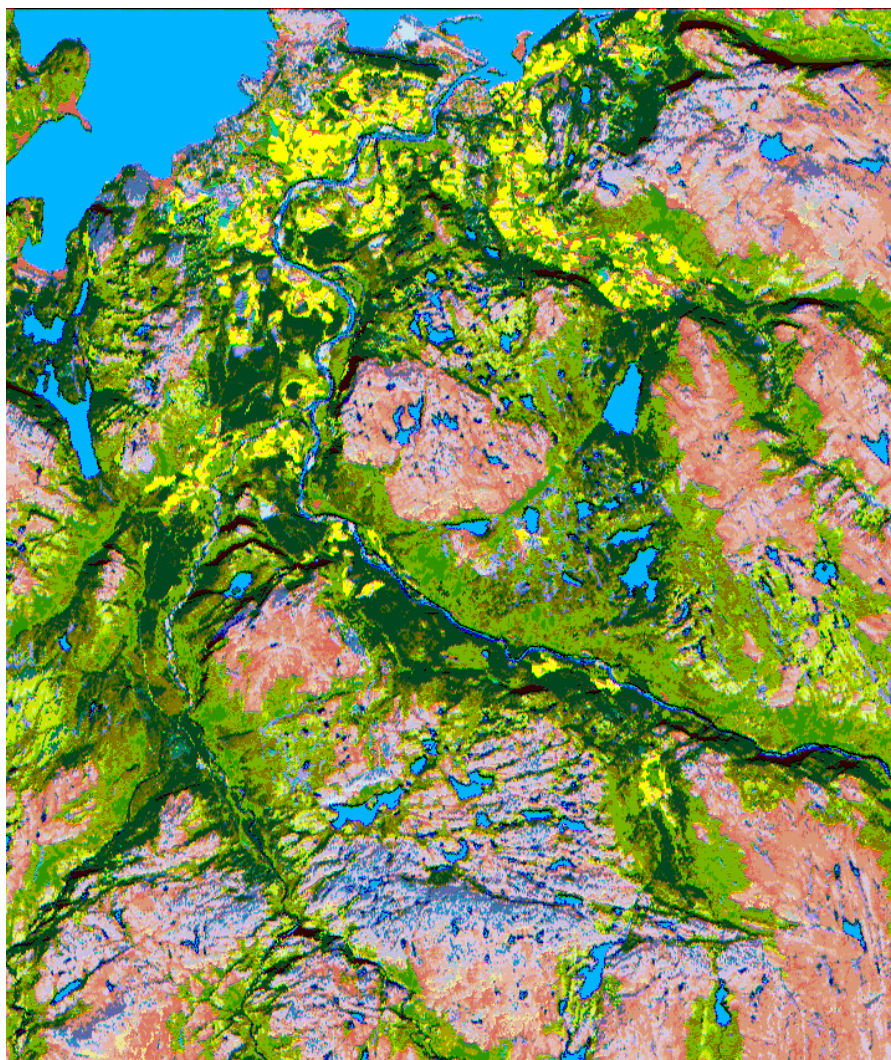


## Map products – Norway (30m resolution)





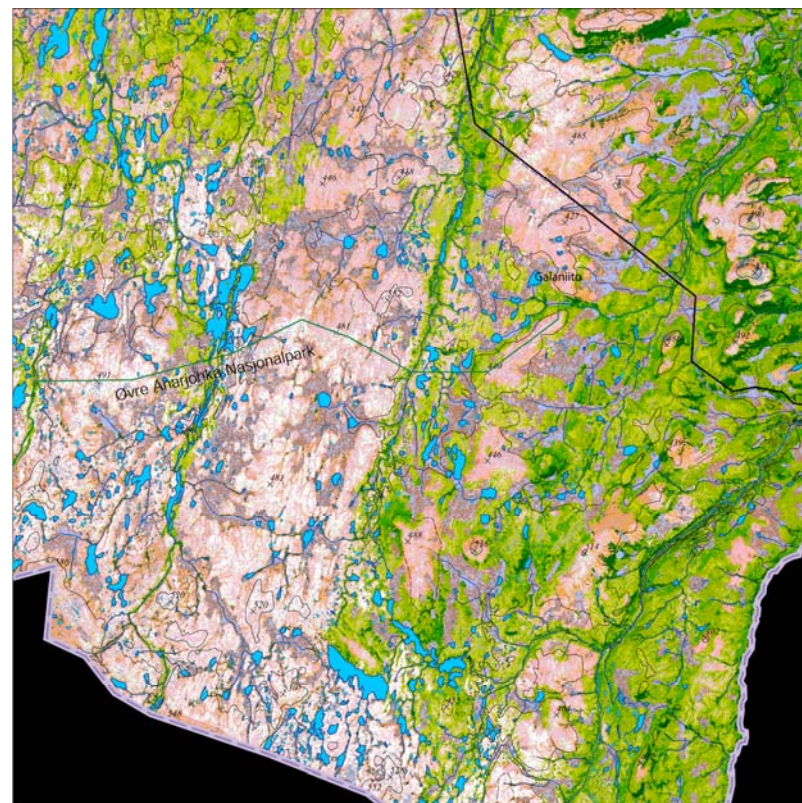
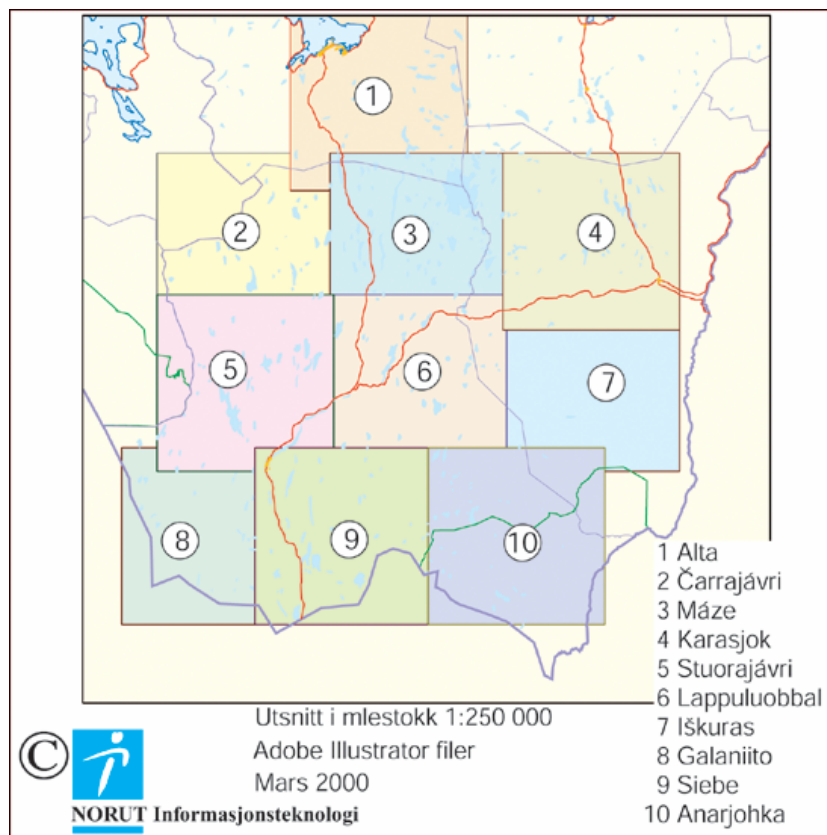
# Map product – class description



- |   |    |  |
|---|----|--|
|    | 1  | Coniferous forest - dense canopy layer |
|    | 2  | Coniferous forest – open canopy layer  |
|    | 3  | Pine forests - lichen type             |
|    | 4  | Mixed forests – pine/birch             |
|    | 5  | Lichen birch woodland                  |
|    | 6  | Mountain birch woodland                |
|    | 7  | Empetrum birch forests                 |
|    | 8  | Gras-rich birch forest                 |
|    | 9  | Bilberry birch forests                 |
|    | 10 | Meadow birch and grey alder forest     |
|    | 11 | Low herb birch forests                 |
|    | 12 | Hummock mire complex                   |
|    | 13 | Lawn and carpet mire complex           |
|    | 14 | Wooded mire complex                    |
|    | 15 | Mud-bottom fens                        |
|    | 16 | Sedge marches                          |
|    | 17 | Exposed gravel ridges                  |
|    | 18 | Open heather communities               |
|    | 19 | Lichen heaths                          |
|    | 20 | Dwarf shrub heaths/established heaths  |
|   | 21 | Moist heather communities              |
|  | 22 | Wet heather communities                |
|  | 23 | Grass heaths                           |
|  | 24 | Mountain meadows                       |
|  | 25 | Sedge and grass snow-bed               |
|  | 26 | Dwarf willow/moss snow-bed             |
|  | 27 | Mid-alpine snow-beds/boulder fields    |
|  | 28 | Gravel ridges and bedrock outcrops     |
|  | 29 | Snow and glaciers                      |
|  | 30 | Water                                  |
|  | 31 | Cultivated areas                       |
|  | 32 | Impediment                             |
|  | 33 | Wetland, shadow effects                |
|  | 34 | Shallow water                          |



# Vegetation maps – Finnmarksvidda



## Vegetasjonstyper

- |                                     |   |
|-------------------------------------|---|
| 1. Furuskog                         | 14. Lavheier  |
| 2. Blandingskog                     | 15. Slitte lavheier                                   |
| 3. Fjellbjrkeskog                   | 16. Blår - grashei                                    |
| 4. Bjrkeskog - tyttebr/kekling type | 17. Engsamfunn  |
| 5. Bjrkeskog - blårtype             | 18. Friske risheier - vierkratt                       |
| 6. Bjrkeskog - rikere utforming     | 19. Lavholdige risheier/krattskog                     |
| 7. Rismyr                           | 20. Snleier - skyggeområder                           |
| 8. Blandet myr                      | 21. Mellomalpine hei- og snleiesamfunn                |
| 9. Gras- og starrmyr                | 22. Eksponerte rabbesamfunn i lg- og mellomalpin sone |
| 10. Blautmyr                        | 23. Blokk- og grusmark                                |
| 11. Vtmark                          | 24. Kulturmark  |
| 12. Rabber og tre risheier          | 25. Vann  |
| 13. Lyng- og risheier               | 26. Snlisbreer  |

## Tegnforklaring

- Distriktsgrænse
- Nasjonalparkgrænse
- Fylkesgrænse
- Kommunegrænse
- Riksvei
- Fylkesvei
- Privat vei
- Traktorvei
- Merket sti
- Sti

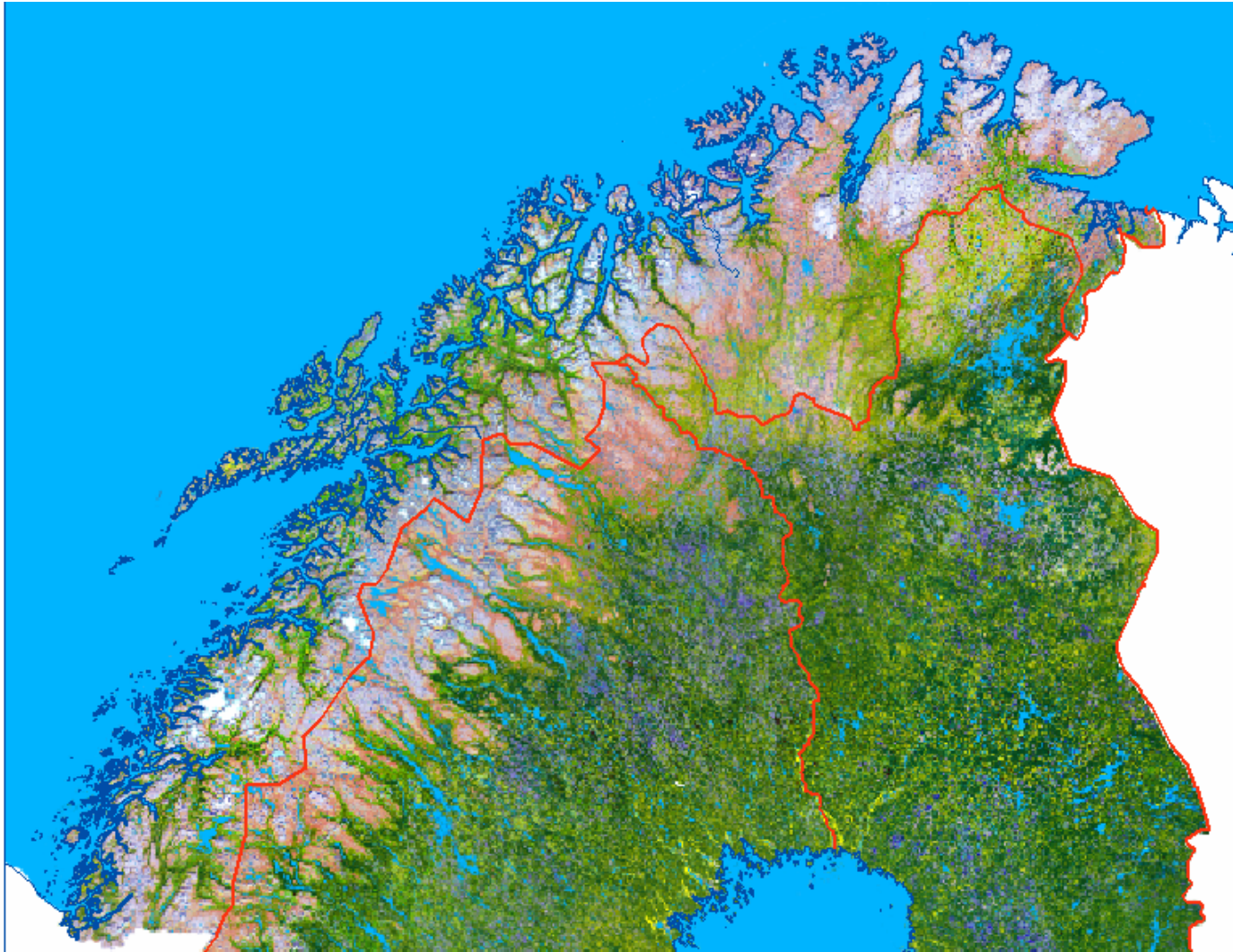


Målestokk 1: 250 000  
0 1 2 3 4 5  
Kilometer



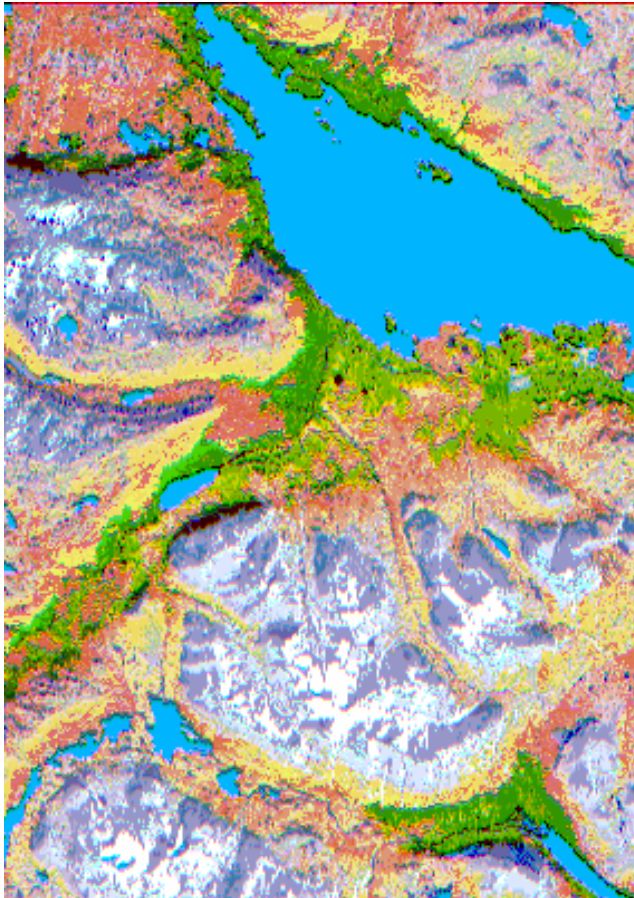
**NORUT** Informasjonsteknologi

## Map products – Norway/Sweden/Finland





## Map comparisons – Abisko/Sweden

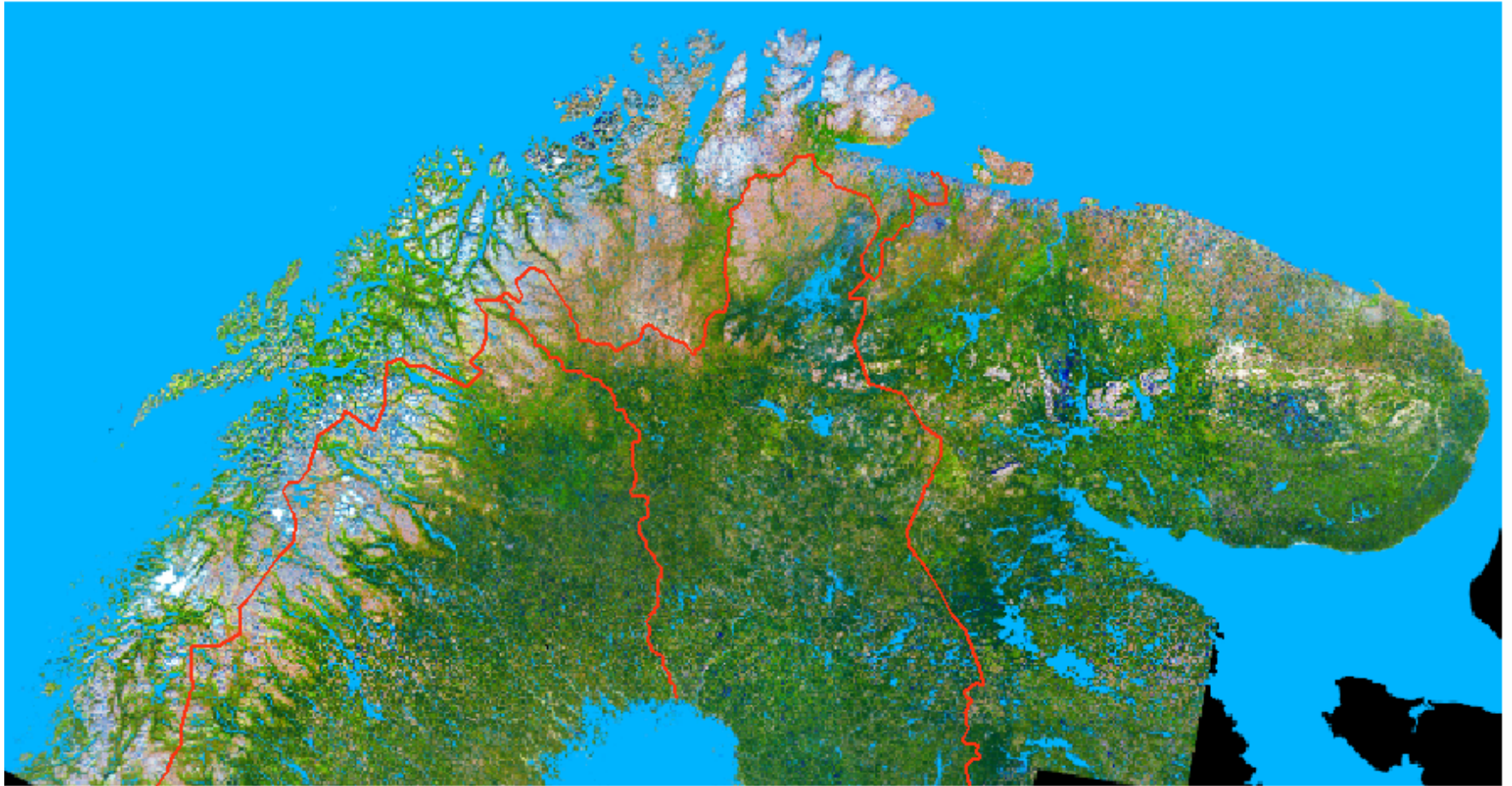


Vegetation map based on Landsat ETM+ data, 27.07.2000. (B. Johansen 2006)



Vegetation map based on traditional methods (L. Anderson 1981)

# Northern Fennoscandia/Kola – overall map

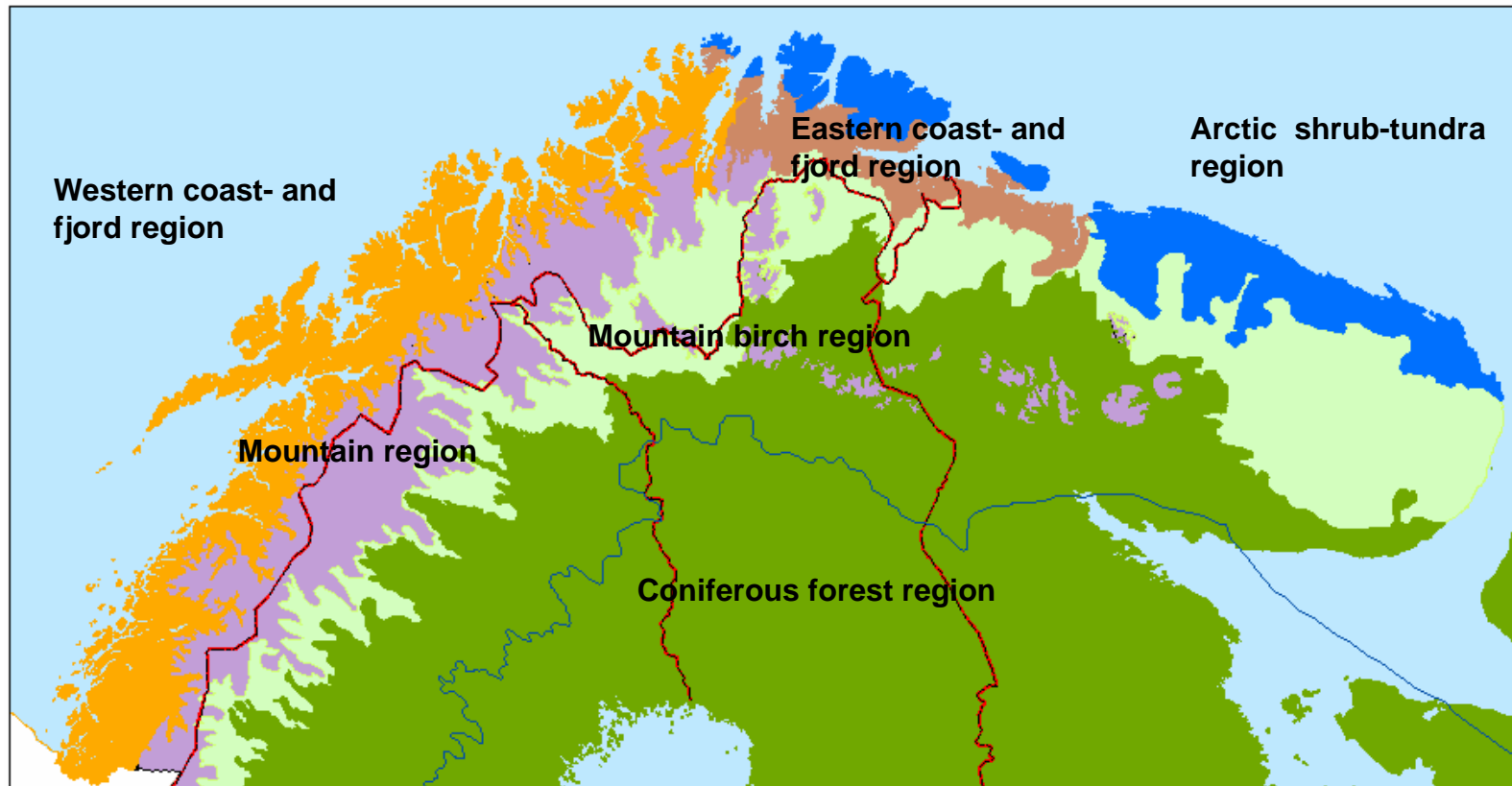




## Example of use (1): Definition of eco-regions



# Eco-regions - outlined



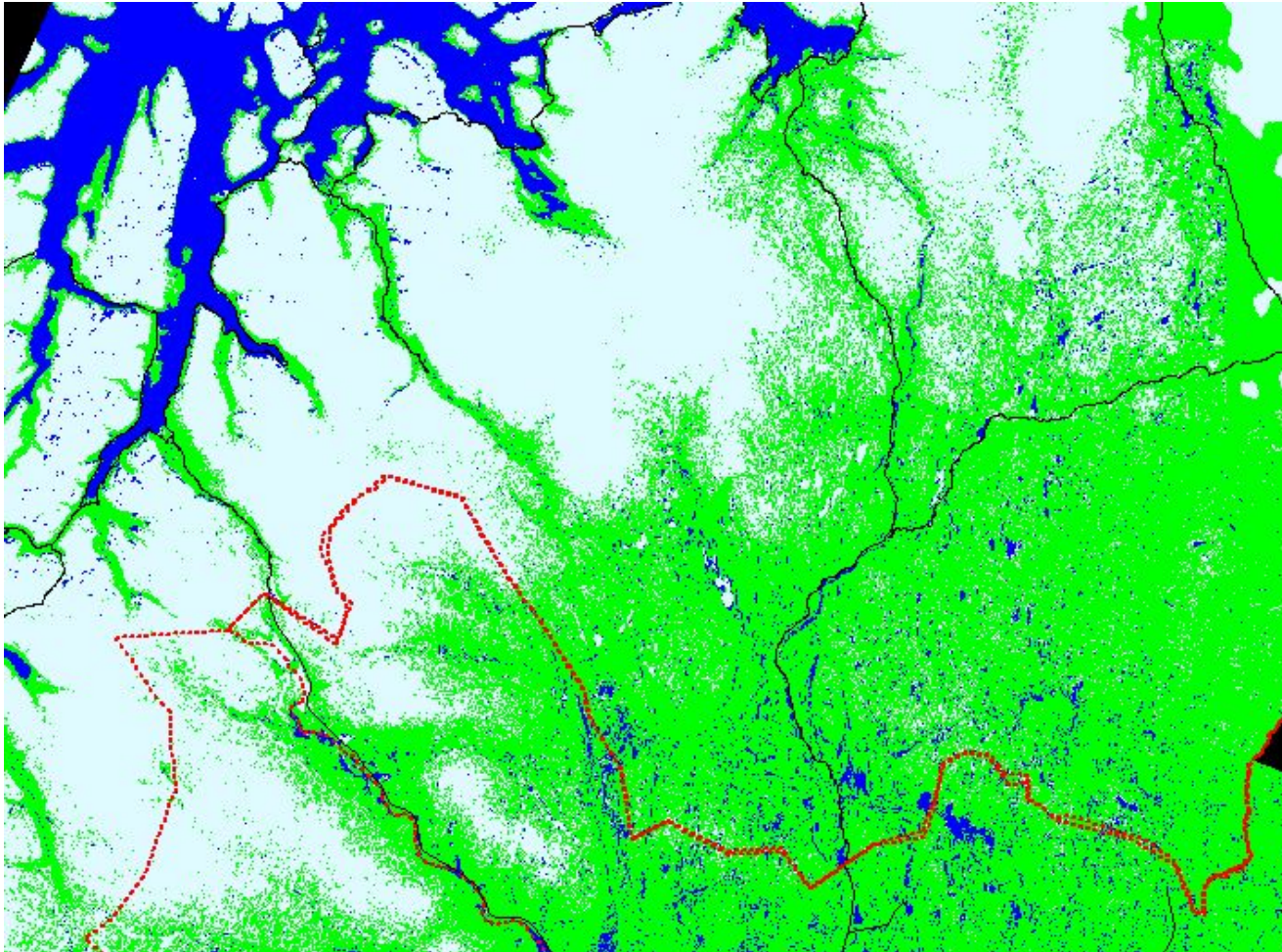


## Example of use (2a): Regional snow pattern





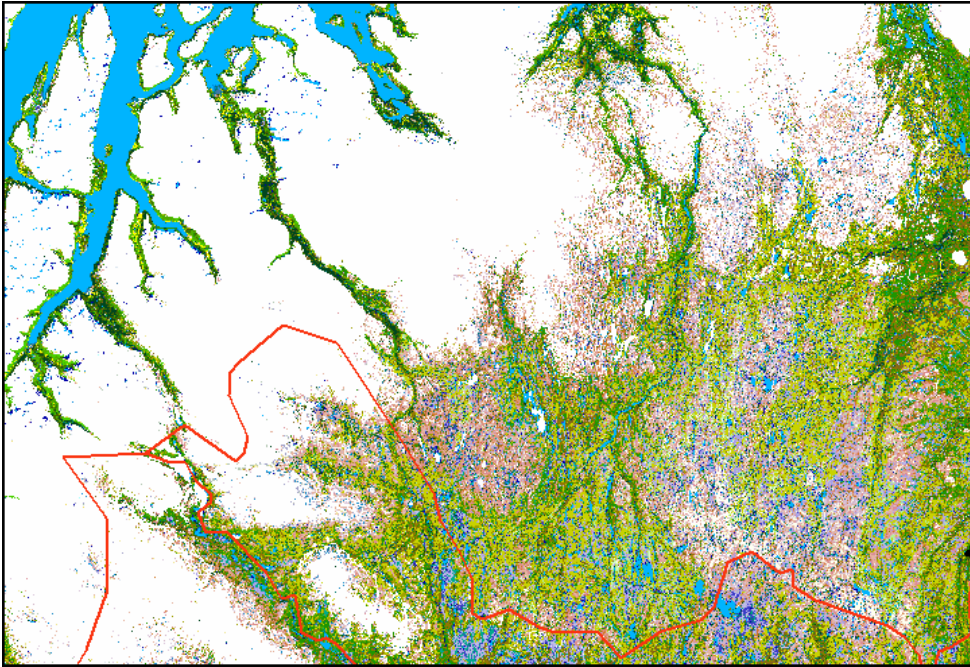
# Troms/Finnmark – snow pattern



Landsat TM images – late May 1994

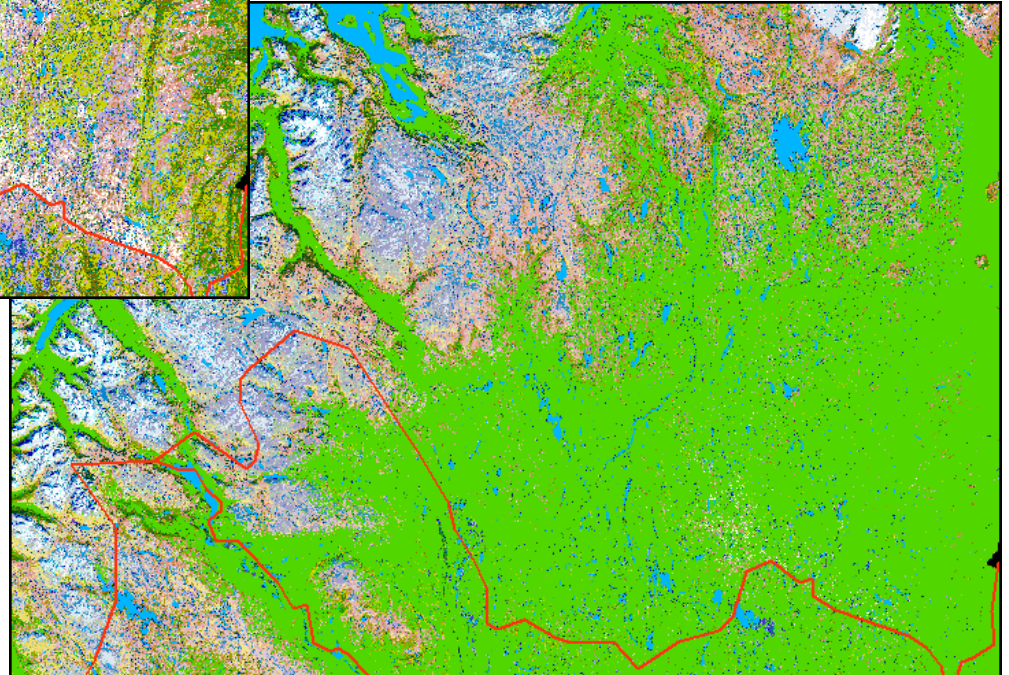


## Example of use (2b): Snow cover analysis



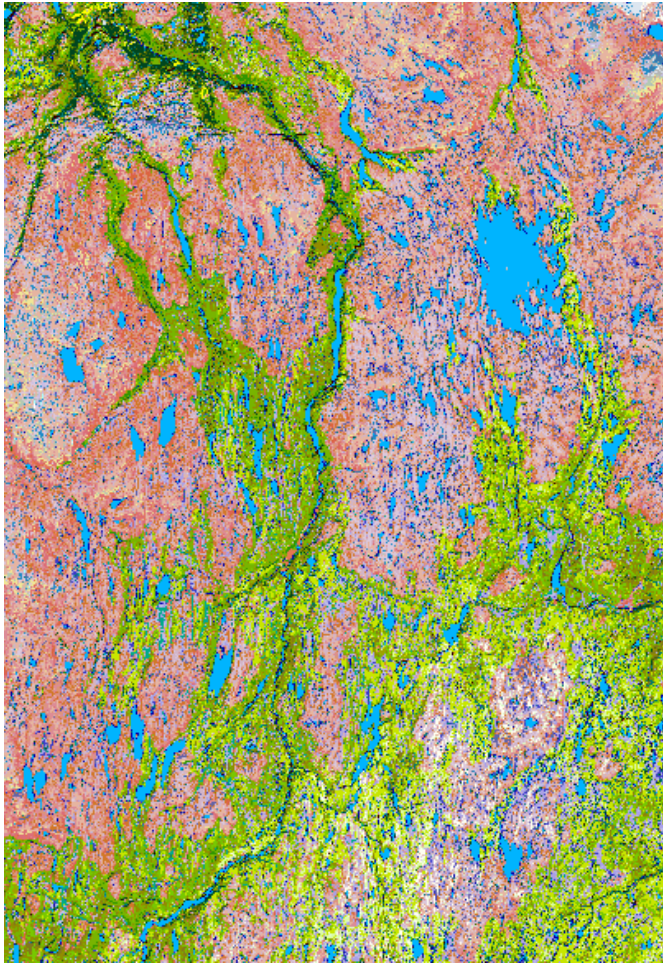
**a) Snowfree areas**

**b) Snowcovered areas**

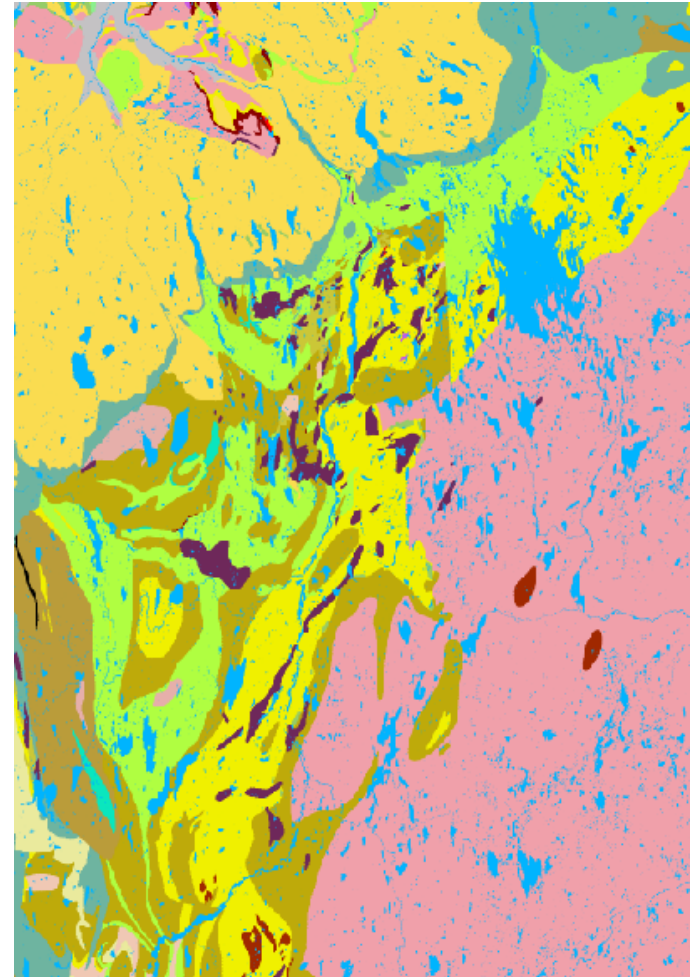




## Example of use (3): Analysis of geology/vegetation cover



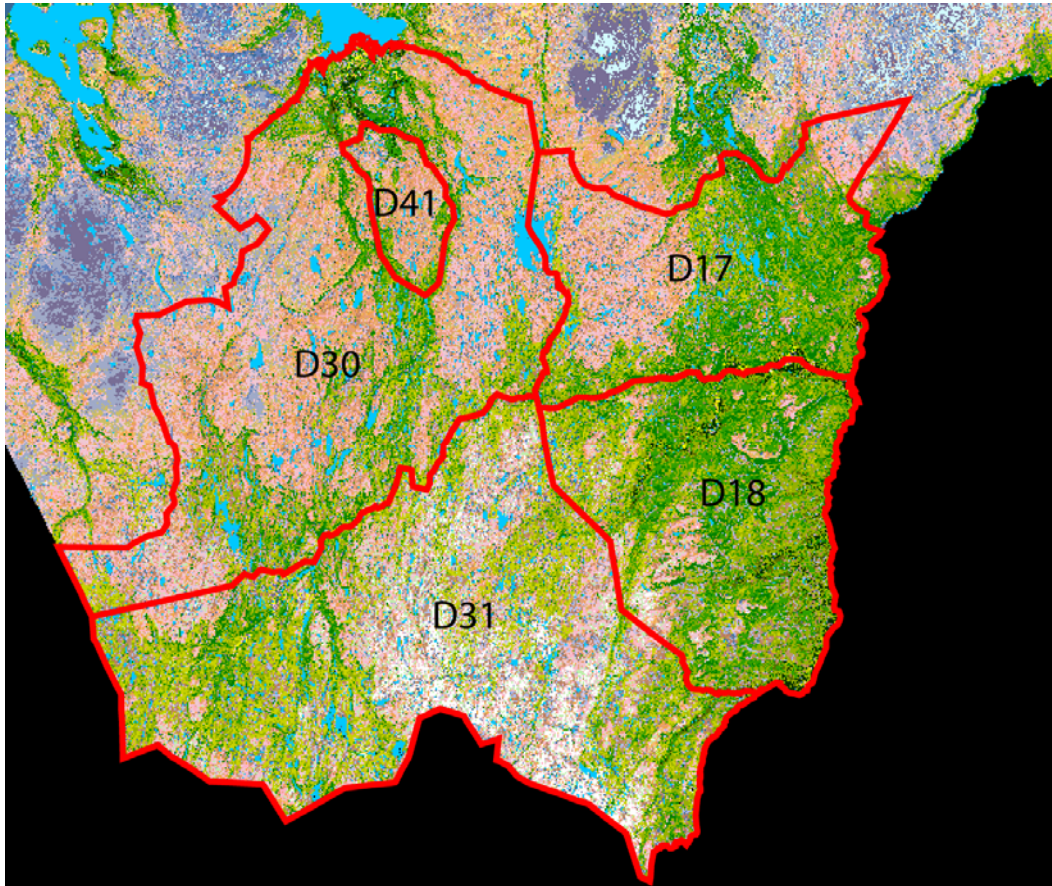
Vegetation map



Geological map



## Example of use (4): Vegetation changes Finnmarksvidda

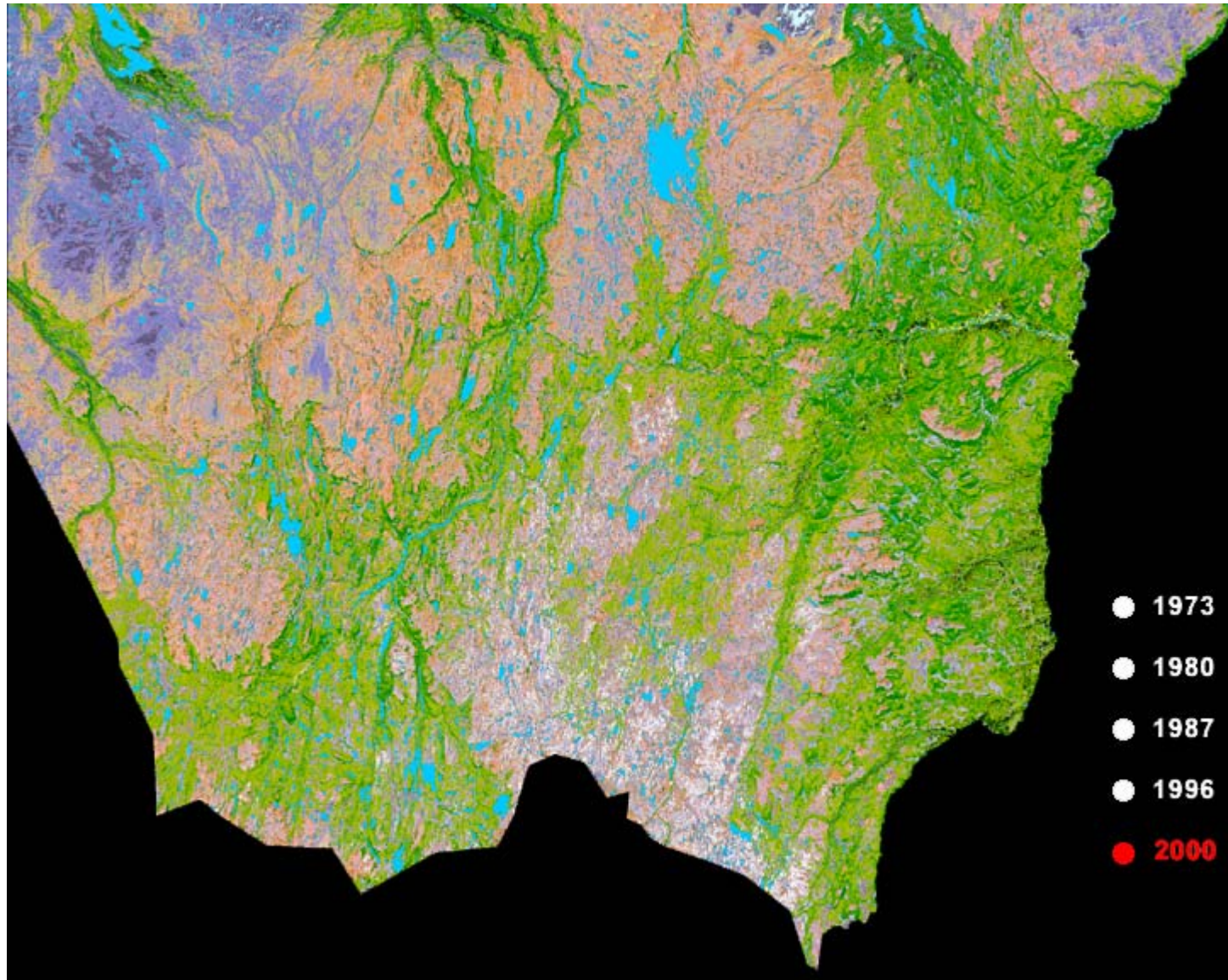


**Summer ranges** - on the islands and peninsulas near the coast

**Spring/fall areas** – middle parts of Finnmarksvidda

**Winter ranges** – southern, continental parts of Finnmarksvidda

- **Arrows:** Migration routes



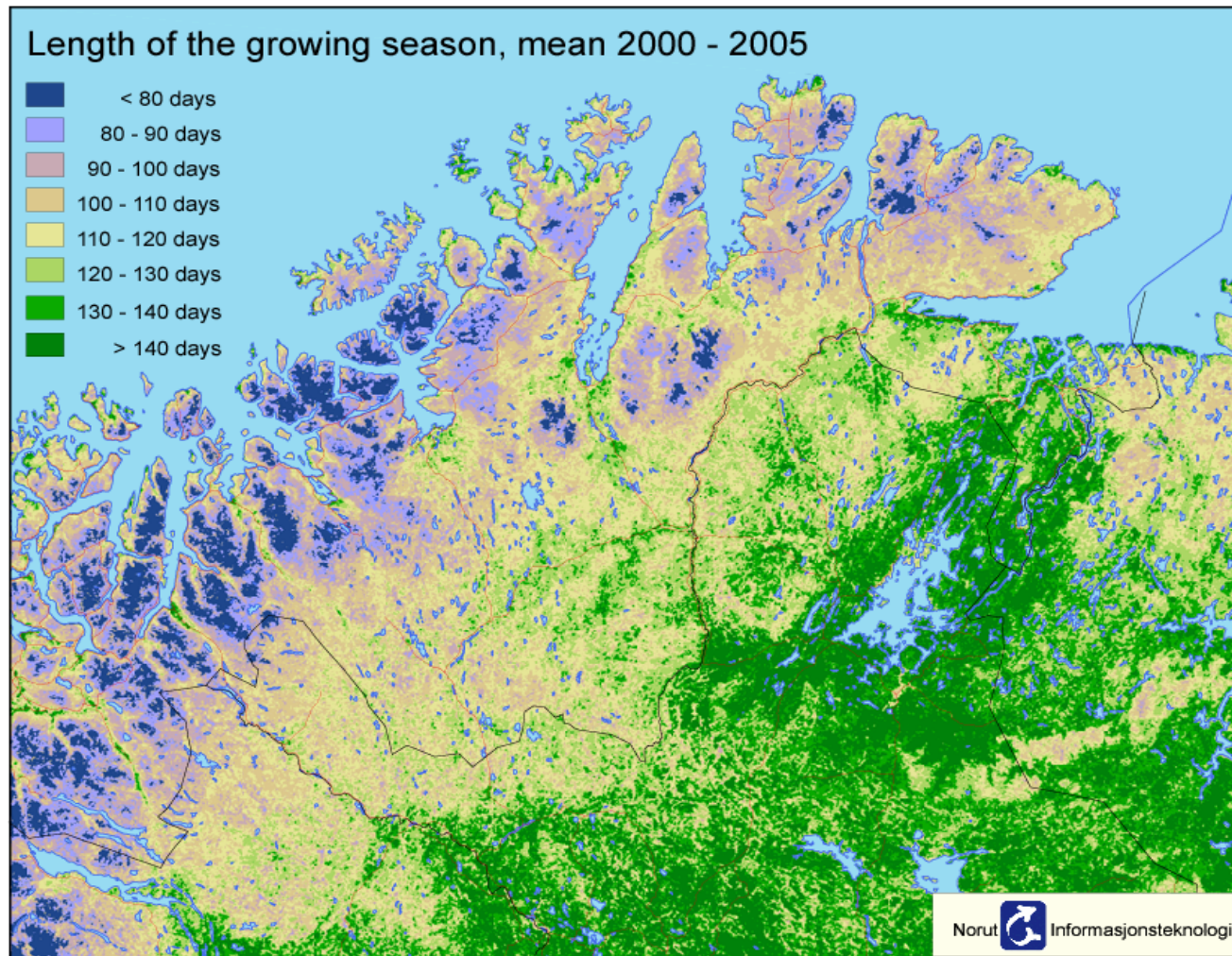


# Changes in lichen cover

- percent of the total area

	1973	1980	1987	1996	2000	Total km2
D17 (s/f)	15,0	15,0	5,7	0,1	0,1	2589,3
D30 (s/f)	30,3	20,1	6,1	0,4	0,2	5331,2
D41 (s/f)	27,1	15,2	4,6	0,0	0,0	399,7
D18 (w)	15,9	14,9	6,9	1,5	0,8	2717,6
D31 (w)	37,7	36,6	25,2	11,9	6,9	5463,9

## Example of use (5): Phenological studies





# Conclusions

- Remote Sensing data is highly relevant for vegetation mapping of large areas like northern Fennoscandia
- Based on satellite data we can perform mapping at different levels: 1) - global (zones/sections) 2) - national level (landscape) and 3) regional/local level (community)
- Based on created maps vegetation monitoring can be performed within selected areas (Finnmarksvidda)
- Remote sensing data are well suited for analyzing changes and trends within vegetation communities
- Use of satellite data are well suited for co-operation within different research areas

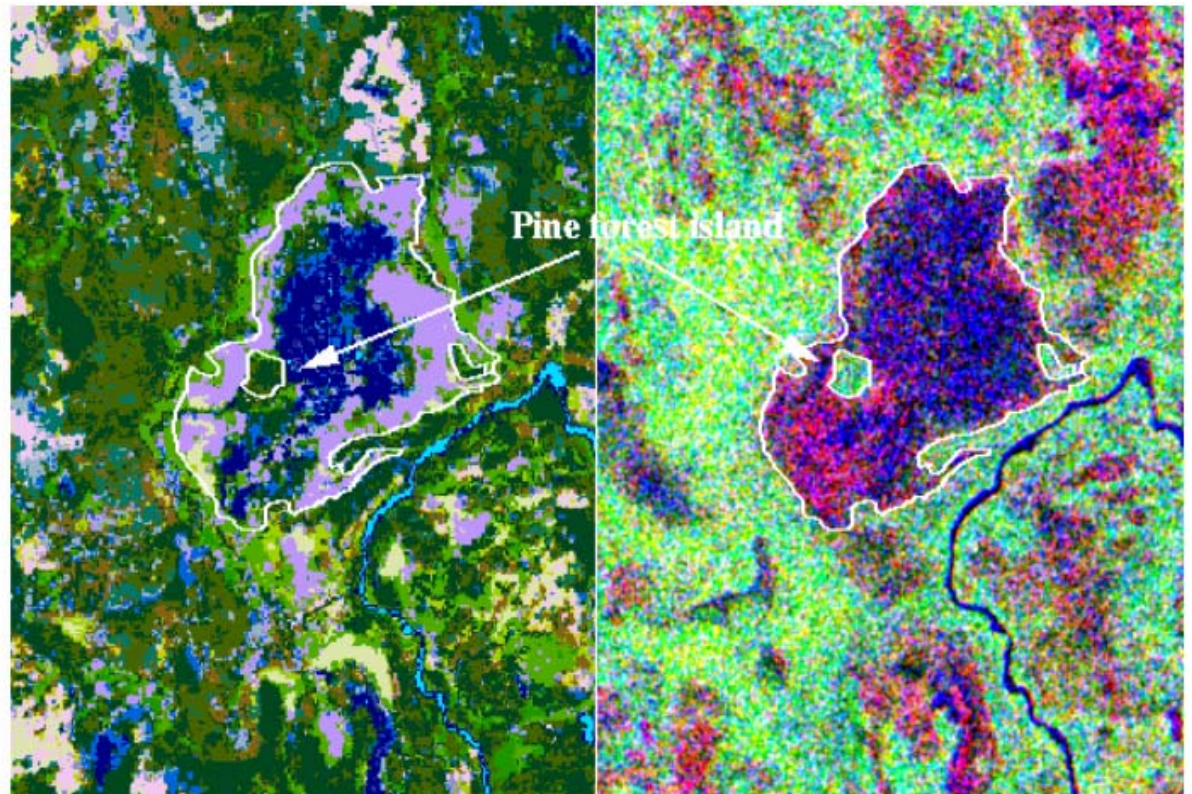
# Conclusions

- The reindeer herding in northern Fennoscandia is adapted to use of large areas
- There is a challenge to create overviews over these areas
- Satellite data can create these overviews at different levels

# Improvements/Further Works

- PC Transform of the SAR time series (cross polarized channel).
- Color composition **Overall High BS.** **Varying BS.** **Overall Low BS**

Pine forest-dense canopy  
 Pine forest - open canopy  
 Pine forests - Lichen type  
 Mixed forests Pine/Birch  
 Lichen Birch woodland  
 Empetrum Birch forests  
 Grass-rich birch forests  
 Bilberry birch forests  
 Tall herb/fern birch forests  
 Low herb birch forests  
 Hummock bogs  
 Fens  
 Willow and gras fens  
 Mud-bottom fens and sedge marches  
 Mud bottom fens and sedge marches  
 Exposed gravel ridges  
 Open heather Communities  
 Lichen heaths  
 Dwarf shrub heaths/established heaths  
 Fresh heaths and grey willow thickets  
 Grass heaths  
 Mountain meadows  
 Snowbed communities  
 wet snowbeds/hummock bogs  
 Water  
 Cultivated areas



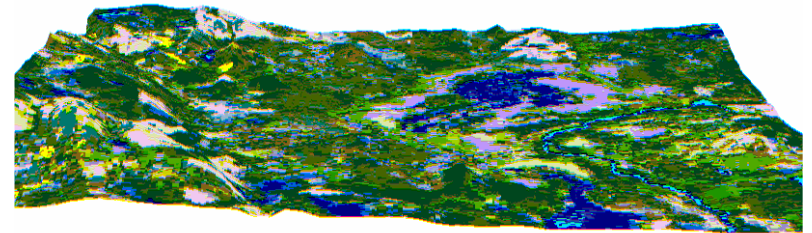
Vegetation map

PC transformed SAR data

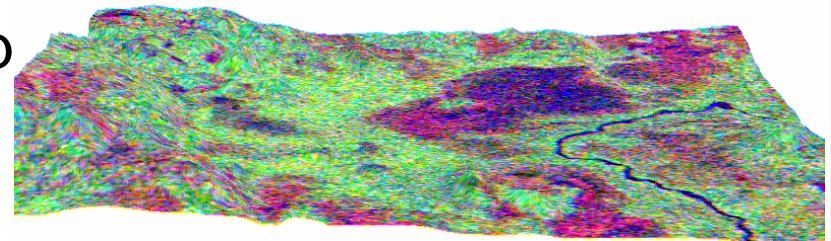


# Comparison of Map and SAR Data

- Mires are located to depressions in the landscape.
- Coniferous forest are located in moraine areas
- Good correspondence between the vegetation map and SAR data.



Vegetation map



PC Transformed SAR data

# Conclusions

- Difficult to distinguish between mires and dense coniferous forest in Landsat images.
- During the snow-melt season there is a significant change in backscatter for mires. In comparison, the backscatter from forested areas can be regarded constant.
- PC Transformation of a SAR time series in the snowmelt season is a nice tool for visualizing mires and forested areas.